

CLAIMS

WHAT IS CLAIMED IS:

1. Magnetic powder composed of an alloy composition represented by  $R_x(Fe_{1-a}Co_a)_{100-x-y-z}B_yM_z$  (where R is at least one kind of rare-earth element excepting Dy, M is at least one kind of element selected from Ti, Cr, Nb, V, Mo, Hf, W, Mn, Zr and Dy, x is 7.1 - 9.9at%, y is 4.6 - 8.0at%, z is 0.1 - 3.0at%, and a is 0 - 0.30), and the magnetic powder being constituted from a composite structure having a soft magnetic phase and a hard magnetic phase,

wherein when the magnetic powder is mixed with a binding resin and then the mixture is subjected to injection molding or extrusion molding to form a bonded magnet having a density  $\rho$  [Mg/m<sup>3</sup>], a maximum magnetic energy product  $(BH)_{max}$  [kJ/m<sup>3</sup>] of the bonded magnet at room temperature satisfies a relationship represented by a formula of  $(BH)_{max}/\rho^2 [\times 10^{-9} J \cdot m^3 / g^2] \geq 2.10$ , and an intrinsic coercive force  $H_{CJ}$  of the bonded magnet at room temperature is in a range of 400 - 760 kA/m.

2. The magnetic powder as claimed in claim 1, wherein a remanent magnetic flux density  $Br$  [T] of the bonded magnet at room temperature satisfies a relationship represented by a formula of

$$Br/\rho [\times 10^{-6} T \cdot m^3 / g] \geq 0.125.$$

3. Magnetic powder composed of an alloy composition represented by  $R_x(Fe_{1-a}Co_a)_{100-x-y-z}B_yM_z$  (where R is at least one kind of rare-earth element excepting Dy, M is at least one kind of element selected from Ti, Cr, Nb, V, Mo, Hf, W, Mn, Zr and Dy, x is 7.1 - 9.9at%, y is 4.6 - 8.0at%, z is 0.1 - 3.0at%, and a is 0 - 0.30), and the magnetic powder being constituted

from a composite structure having a soft magnetic phase and a hard magnetic phase,

wherein when the magnetic powder is mixed with a binding resin and then the mixture is subjected to injection molding or extrusion molding to form a bonded magnet having a density  $\rho$  [Mg/m<sup>3</sup>], a remanent magnetic flux density  $B_r$  [T] of the bonded magnet at room temperature satisfies a relationship represented by a formula of  $B_r/\rho$  [ $\times 10^{-6}$  T·m<sup>3</sup>/g]  $\geq 0.125$  and an intrinsic coercive force  $H_{ci}$  of the bonded magnet at room temperature is in a range of 400 - 760 kA/m.

4. The magnetic powder as claimed in claim 1, wherein the magnetic powder is obtained by milling a melt spun ribbon.

5. The magnetic powder as claimed in claim 4, wherein a thickness of the melt spun ribbon is 10 - 40  $\mu$ m.

6. The magnetic powder as claimed in claim 4, wherein the melt spun ribbon is obtained by colliding a molten alloy of a magnetic material onto a circumferential surface of a cooling roll which is rotating to cool and then solidify it.

7. The magnetic powder as claimed in claim 6, wherein the cooling roll includes a roll base made of a metal or an alloy and an outer surface layer provided on an outer peripheral portion of the roll base to constitute the circumferential surface, in which the outer surface layer of the cooling roll has a heat conductivity lower than a heat conductivity of the roll base.

8. The magnetic powder as claimed in claim 7, wherein the outer surface layer of the cooling roll is formed of a ceramic.

9. The magnetic powder as claimed in claim 1, wherein said R comprises rare-earth elements mainly containing Nd and/or Pr.

10. The magnetic powder as claimed in claim 1, wherein said R includes Pr and its ratio with respect to a total mass of said R is 5 - 75%.

11. The magnetic powder as claimed in claim 1, wherein the composite structure includes a nanocomposite structure.

12. The magnetic powder as claimed in claim 1, wherein the magnetic powder is subjected to a heat treatment at least once during a manufacturing process or after its manufacture.

13. The magnetic powder as claimed in claim 1, wherein a mean crystal grain size of the magnetic powder is 5 - 50nm.

14. The magnetic powder as claimed in claim 1, wherein an average particle size of the magnetic powder is 0.5 - 150 $\mu$ m.

15. A method of manufacturing magnetic powder, in which a melt spun ribbon is obtained by colliding a molten alloy of a magnetic material onto a circumferential surface of a cooling roll which is rotating to cool

and then solidify it, and then thus obtained melt spun ribbon is milled to obtain the magnetic powder, in which the magnetic powder is composed of an alloy composition represented by  $R_x(Fe_{1-a}Co_a)_{100-x-y-z}B_yM_z$  (where R is at least one kind of rare-earth element excepting Dy, M is at least one kind of element selected from Ti, Cr, Nb, V, Mo, Hf, W, Mn, Zr and Dy, x is 7.1 - 9.9at%, y is 4.6 - 8.0at%, z is 0.1 - 3.0at%, and a is 0 - 0.30), and the magnetic powder being constituted from a composite structure having a soft magnetic phase and a hard magnetic phase, wherein when the magnetic powder is mixed with a binding resin and then the mixture is subjected to injection molding or extrusion molding to form a bonded magnet having a density  $\rho$  [Mg/m<sup>3</sup>], a maximum magnetic energy product  $(BH)_{max}$  [kJ/m<sup>3</sup>] of the bonded magnet at room temperature satisfies a relationship represented by a formula of  $(BH)_{max}/\rho^2 [\times 10^{-9} J \cdot m^3 / g^2] \geq 2.10$ , and an intrinsic coercive force  $H_{ci}$  of the bonded magnet at room temperature is in a range of 400 - 760 kA/m.

16. A method of manufacturing magnetic powder, in which a melt spun ribbon is obtained by colliding a molten alloy of a magnetic material onto a circumferential surface of a cooling roll which is rotating to cool and then solidify it, and then thus obtained melt spun ribbon is milled to obtain the magnetic powder, in which the magnetic powder being composed of an alloy composition represented by  $R_x(Fe_{1-a}Co_a)_{100-x-y-z}B_yM_z$  (where R is at least one kind of rare-earth element excepting Dy, M is at least one kind of element selected from Ti, Cr, Nb, V, Mo, Hf, W, Mn, Zr and Dy, x is 7.1 - 9.9at%, y is 4.6 - 8.0at%, z is 0.1 - 3.0at%, and a is 0 - 0.30), and the magnetic powder being constituted from a composite structure having a soft magnetic phase and a hard magnetic phase, wherein when the magnetic powder is mixed with a binding resin and then the mixture is subjected to

injection molding or extrusion molding to form a bonded magnet having a density  $\rho$  [Mg/m<sup>3</sup>], a remanent magnetic flux density  $B_r$  [T] of the bonded magnet at room temperature satisfies a relationship represented by a formula of  $B_r/\rho$  [ $\times 10^{-6}$  T·m<sup>3</sup>/g]  $\geq 0.125$ , and an intrinsic coercive force  $H_{CJ}$  of the bonded magnet at room temperature is in a range of 400 - 760 kA/m.

17. A bonded magnet manufactured by mixing magnetic powder with a binding resin and then subjecting the mixture to injection molding or extrusion molding, in which the magnetic powder is composed of an R-TM-B based alloy having at least one element selected from Ti, Cr, Nb, V, Mo, Hf, W, Mn, Zr and Dy (where R is at least one kind of rare-earth element excepting Dy, and TM is a transition metal mainly containing Fe), the bonded magnet being characterized in that when a density of the bonded magnet is  $\rho$  [Mg/m<sup>3</sup>], a maximum magnetic energy product  $(BH)_{\max}$  [kJ/m<sup>3</sup>] of the bonded magnet at room temperature satisfies a relationship represented by a formula of  $(BH)_{\max}/\rho^2$  [ $\times 10^{-9}$  J·m<sup>3</sup>/g<sup>2</sup>]  $\geq 2.10$ , and an intrinsic coercive force  $H_{CJ}$  of the bonded magnet at room temperature is in a range of 400 - 760 kA/m.

18. The bonded magnet as claimed in claim 17, wherein a remanent magnetic flux density  $B_r$  [T] of the bonded magnet at room temperature satisfies a relationship represented by a formula of  $B_r/\rho$  [ $\times 10^{-6}$  T·m<sup>3</sup>/g]  $\geq 0.125$ .

19. A bonded magnet manufactured by mixing magnetic powder with a binding resin, and then subjecting the mixture to injection molding or extrusion molding, wherein the magnetic powder being composed of an R-TM-B based alloy having at least one element selected from Ti, Cr, Nb, V, Mo,

Hf, W, Mn, Zr and Dy (where R is at least one kind of rare-earth element excepting Dy, and TM is a transition metal mainly containing Fe), the bonded magnet being characterized in that when a density of the bonded magnet is  $\rho$  [Mg/m<sup>3</sup>], a remanent magnetic flux density  $B_r$  [T] of the bonded magnet at room temperature satisfies a relationship represented by a formula of  $B_r/\rho$  [ $\times 10^{-6}$  T·m<sup>3</sup>/g]  $\geq 0.125$ , and an intrinsic coercive force  $H_{ci}$  of the bonded magnet at room temperature is in a range of 400 - 760 kA/m.

20. The bonded magnet as claimed in claim 17, wherein the magnetic powder is composed of an alloy composition represented by  $R_x(Fe_{1-a}Co_a)_{100-x-y-z}B_yM_z$  (where R is at least one kind of rare-earth element excepting Dy, M is at least one kind of element selected from Ti, Cr, Nb, V, Mo, Hf, W, Mn, Zr and Dy, x is 7.1 - 9.9at%, y is 4.6 - 8.0at%, z is 0.1 - 3.0at%, and a is 0 - 0.30), and the magnetic powder is constituted from a composite structure having a soft magnetic phase and a hard magnetic phase.

21. The bonded magnet as claimed in claim 17, wherein a maximum magnetic energy product  $(BH)_{max}$  [kJ/m<sup>3</sup>] is equal to or greater than 40kJ/m<sup>3</sup>.

22. The bonded magnet as claimed in claim 16, wherein an absolute value of an irreversible flux loss (initial flux loss) is equal to or less than 6.2%.

23. The magnetic powder as claimed in claim 3, wherein the magnetic powder is obtained by milling a melt spun ribbon.

24. The magnetic powder as claimed in claim 24, wherein a

thickness of the melt spun ribbon is 10 - 40 $\mu$ m.

25. The magnetic powder as claimed in claim 24, wherein the melt spun ribbon is obtained by colliding a molten alloy of a magnetic material onto a circumferential surface of a cooling roll which is rotating to cool and then solidify it.

26. The magnetic powder as claimed in claim 25, wherein the cooling roll includes a roll base made of a metal or an alloy and an outer surface layer provided on an outer peripheral portion of the roll base to constitute the circumferential surface, in which the outer surface layer of the cooling roll has a heat conductivity lower than a heat conductivity of the roll base.

27. The magnetic powder as claimed in claim 26, wherein the outer surface layer of the cooling roll is formed of a ceramic.

28. The magnetic powder as claimed in claim 3, wherein said R comprises rare-earth elements mainly containing Nd and/or Pr.

29. The magnetic powder as claimed in claim 3, wherein said R includes Pr and its ratio with respect to a total mass of said R is 5 - 75%.

30. The magnetic powder as claimed in claim 3, wherein the composite structure includes a nanocomposite structure.

31. The magnetic powder as claimed in claim 3, wherein the magnetic powder is subjected to a heat treatment at least once during a manufacturing process or after its manufacture.

32. The magnetic powder as claimed in claim 3, wherein a mean crystal grain size of the magnetic powder is 5 - 50nm.

33. The magnetic powder as claimed in claim 3, wherein an average particle size of the magnetic powder is 0.5 - 150 $\mu$ m.

34. The bonded magnet as claimed in claim 19, wherein the magnetic powder is composed of an alloy composition represented by  $R_x(Fe_{1-a}Co_a)_{100-x-y-z}B_yM_z$  (where R is at least one kind of rare-earth element excepting Dy, M is at least one kind of element selected from Ti, Cr, Nb, V, Mo, Hf, W, Mn, Zr and Dy, x is 7.1 - 9.9at%, y is 4.6 - 8.0at%, z is 0.1 - 3.0at%, and a is 0 - 0.30), and the magnetic powder is constituted from a composite structure having a soft magnetic phase and a hard magnetic phase.

35. The bonded magnet as claimed in claim 19, wherein a maximum magnetic energy product  $(BH)_{max}$  [kJ/m<sup>3</sup>] is equal to or greater than 40kJ/m<sup>3</sup>.

36. The bonded magnet as claimed in claim 17, wherein an absolute value of an irreversible flux loss (initial flux loss) is equal to or less than 6.2%.